PLC Courses Give No Excuse to Dumb Down

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Abstract

A primary goal of a course in Programmable Controller Applications is to help the student find good employment. Another goal of the course should also be to support other subjects taught in the digital sequence as well as networking and programming.

The PLC was first brought to market around 1970 and the UAW went to the big three auto-makers with the proposition that they would endorse it if it was made available exclusively to electricians to program. This was agreed between the parties and the PLC was mainly programmed by electricians using existing control diagrams. In other environments, the PLC was programmed by engineers and later by engineering technologists (EET's). The PLC never fully utilized in those early years the complete capability of the computer from which it evolved. There was a 'dumbing down' of the instruction set for many years and only recently has this trend been fully reversed.

There is a concern for the lack of student awareness of the high expectations of PLC work once the student graduates. It is commonly accepted that 90% of the jobs in the mid-west served by this university require some proficiency in the use of PLCs. One person who had hired over 20 EET majors in the past few years observed that the EET majors all had some PLC experience and knew how to 'hit the ground running'. Most companies today do not want to spend money trying to convince the recent graduate that programming the PLC is something worthwhile. They want the student already convinced and willing to accept the challenges of program creation from day one.

The approach of the courses outlined here is in general more rigorous than that encouraged by most American PLC texts[1][2][3][4][5]. Encouraged from the first is the writing of programs from scratch. Several clues are given along the way but students are encouraged to begin writing their own programs and debugging them in order to get credit for the project. Projects are used instead of projects. In a project the student must complete a working model in order to get credit. There is no guarantee that after an hour or two or three the program will be working and accepted. It may take longer – much longer.

Programs include a traffic intersection, a simple cash register, and a simple candy dispenser machine. Programming moves to more difficult programs involving number conversion to bit logic and programs requiring the use of timing diagrams. Then more difficult programs including sequencing of data and moving data through tables are required.

The paper develops a list of topics that are covered in a comprehensive PLC course. Rational for inclusion of various topics are discussed as well as the name change to Mechatronics from PLC.

Experience teaching Three PLC Courses

PLC courses are taught in both Electrical Engineering and in Electrical Engineering Technology at the University. The EET program has two PLC courses, one at the junior level and one at the senior level. These were both the result over the years of IAB recommendations. A difficult part of teaching the two courses is that there has been a need to retreat into the first course while teaching the second due to lack of adequate student preparation from students entering the program as transfers.

A single EECS course teaches concepts of the PLC using the same book and project material.

The intent of all these courses is to expose the student to as many different programming experiences as possible.

History of PLC and PLC Education

The PLC was first brought to market around 1968 and the UAW went to the big three auto-makers with the proposition that they would endorse it if it was made available exclusively to electricians to program. This was agreed between the parties and the PLC was mainly programmed by electricians using existing control diagrams of machines using relays or by engineers at OEM companies supplying the machine. The PLC was programmed mainly by engineers and later by engineering technologists (EET's) in most applications except those directly affected by the UAW agreement. The PLC never fully utilized in those early years the complete capability of the computer. There was a 'dumbing down' of the instruction set for many years. Over the years, this trend been reversed as competition from outside the US took more and more market share away from the original PLC vendors.

Siemens, Germany's leading PLC manufacturer, has taken a different approach. The approach was much more highly technical and is outlined in the quote below:

From Choosing a PLC from *Milestones in Automation* by Arnold Zankl – Siemens: (pg 54)
"Siemens had at first used STL programming exclusively and been very successful with it. It seemed reasonable to program something in the way people think of it and describe it verbally. High education standards in Germany and Europe also supported this approach.

In the USA, where training for skilled workers was generally less intensive than in other countries, the ladder diagram, derived from the circuit diagram, dominated from the start."

While these statements from Siemens may seem arrogant, they are true. Decisions affecting the instructions and languages allowed have affected the PLC texts and course material from the beginning to now. The US has paid a price for not pushing the development of the PLC past the domain of the electrician. Expectation for PLC education should have been higher.

PLC Experiences

It has been the responsibility of the EET programs at many universities to set the expectation for the PLC course(s). If not at a level to support training that includes program development, the student is not well served.

The project experiences outlined below are an attempt at a standard for project/programming experiences that should form the basis for acceptable coursework in the study of the PLC. These project experiences are outlined in the table below. They vary from very simple combinational logic programs to advanced motion and PID programming for industry. Each project requires the program to be written, wired, and demonstrated to gain credit for the particular project. The difficulty of the projects increased week by week. The only difference between these projects and projects in other courses was that credit is not given until the project works completely. The courses maintain that students could learn both Allen-Bradley and Siemens simultaneously by moving back and forth between the two as they progressed through the projects. The EET courses force students to perform projects using both platforms for full credit with each assignment. The list of projects constitutes the entire list for both EET courses.

The only difference between the EET and EECS courses was that EECS students moved at a faster rate and programmed a different project each week. It has been noted that there were complaints about the amount of work expected in both the EET and EECS student.

Assignment Sheet for EECS 4220: (also EET 2410 and EET 4550)

Project Assn 1 Due 9-7-16	Project 2.1	Explained in Ch. 2, pg 27-32	Results with report
Project Assn 2 Due 9-12-15	Project 4.1	Ch. 4, Hot Dog Counter	Demo with both AB and Siemens Processors with report
Project Assn 3 Due 9-19-16	Project 5.1	Ch. 5, Coin Changer (35-cent option)	Demo with either A-B or Siemens Processors with report
Project Assn 4 Due 9-26-16	Ch. 7	7.1 Traffic Intersection (7.1D)	Demo with either A-B or Siemens Processors with report
Project Assn 5 Due 10-5-16	Ch. 7	7.2 Cash Register (7.2E)	Demo with either A-B or Siemens Processors with report
Project Assn 6 Due 10-10-16	Ch. 8	8.1b (subtract)	Demo with either A-B or Siemens Processors with report
Project Assn 7 Due 10-17-16	Ch. 10	10.1 (MUX)	Demo with either A-B or Siemens Processors with report
Project Assn 8 Due 10-24-16	Ch. 11	11.1(Three Pumps_ Option 11.1.2	Demo with either A-B or Siemens Processors with report
Project Assn 9 Due 10-31-16	Ch. 13	13.1.1A Simon or 13.2b Whack-a-mole	Demo with either A-B or Siemens Processors with report
Project Assn 10 Due 11-7-16	Ch. 14	Project 14.1 (Ch. 14, pg. 32)	Demo with Siemens Processor with report
Project Assn 11 Due 11-14-16	Ch. 15	Project 15.1	Demo with either A-B or Siemens Processors with report

Project Assn 12 Due 11-21-16	Ch. 15	Project 15.2	Demo with either A-B or Siemens Processors with report
Project Assn 13 Due 11-28-16	Ch. 17	Project 17.1 or Project 17.2	Demo with either A-B or Siemens Processors with report
Project Assn 14 Due 12-5-16	Ch. 19	Project 19.1 or Project 19.2	Demo with either A-B or Siemens Processors with report

Overall, project experiences were designed to allow a large number of teams to perform the same experience at the same time. Most projects allow eight or more groups to do the same project at the same time. While this approach of multiple project stations for an individual project was not always the norm, since it was implemented, projects have run much better.

Included in each chapter and project experience are the specifications or applicable codes pertaining to the subject discussed. For example, the ISA specification for HMI panels was discussed as well as organizational methods useful for a new HMI developer. Books containing specific information on these subjects is discussed as well [6][7][8]. When discussing the motion application, codes applicable to moving machinery were included.

Both the EECS and EET courses are based on a commitment to modeling of a process. If memory circuits are discussed, their use in filling of a tank or running of a conveyor was given as an example. Coupling a number of memory circuits when running a number of conveyors expands on the basic concept. If timers can be coupled with a memory circuit, their use in a motor starter circuit was given as an example. Each circuit is coupled to an idea used in industry. The idea of the mechatronics name is based on the concept of using the PLC to control a specific machine or part of a machine.

Sensors are discussed as well as panel design. Safety inside the panel and in the process was also included. Specifications pertaining to each are annotated as they pertain to the application. Each portion of the design is discussed along with a time-line discussing the flow of the engineering process.

There is also an emphasis on writing of Ladder logic without the physical running of a process. When to write a memory circuit is discussed. Differences between types of memory circuits is discussed as well and students are required to convert from type to type thus mastering their knowledge of different types of memory circuits. One-shot logic is discussed and applications requiring one-shots are examined.

Students are introduced to use of state diagrams in PLC programming. There is a close analogy between design of state diagrams and the PLC program. The different methods of generating a state diagram are discussed as well.

Safety from a number of different sources is analyzed. Building of a control panel is also discussed.

The first course for EETs ends with an analysis of a specification regarding batch control. The analysis of batch control from a novice is rather difficult and review of a specification on the subject makes the understanding of how to build a successful batch application much easier. Using a specification to help in the design of a program is important and must be a part of courses such as these.

Also discussed is the specific PLC brand and issues pertaining to the manufacturer's specific requirements. Future employers are paying for students proficient in specific software packages such as Allen-Bradley's RSLogix 5000 or Siemens TIA. Both of these packages are used. Both are emphasized and required. Students must complete the same project in both environments to get credit for many of the projects.

Also, memory and addressing concerns are addressed on a manufacturer specific platform. The student is expected to know the addressing of specific manufacturers' equipment and Siemens and A-B are by far the top two in the PLC environment. They should be emphasized. Also, using the A-B and Siemens platform allow questions on homework and tests that contrast and compare the two. These questions are very good for drawing comparisons between the two as well as giving students a good over-view that the two are not all that different.

Expectations

It is the goal of these courses to bring a student to the point that upon graduation and moving to an manufacturing environment, the student feels comfortable walking into a project planning meeting and able to contribute to conceptually formulate program segments and potential hardware architectures to implement the process being discussed. If they are in a maintenance environment, they should be relied on to discuss potential debugging methods for major problems at hand. In general, they should be able to contribute in a positive manner. They should know the questions to ask and be able to move quickly toward solutions to questions for which they may not have an immediate answer.

While these courses may have found a home at some universities, there are a number that have not adopted them. They may reside in the instrumentation or devices courses but not in a course primarily focused on the PLC. Not considering these courses for EECS students is a mistake.

Projects May Be Used In Multiple Courses

While the equipment of these projects is useful for the PLC courses, specific experiments may also have potential use in other courses including Automatic Controls. The equipment has use in a number of different courses and can be given over to a multitude of uses as need arises. While the courses described are difficult and time consuming for student and instructor alike, the enjoyment that the professor may have after teaching these courses should be noted. As the student moves through the course(s), they begin to enjoy the challenge of the next project and what lies ahead while seeing the potential for creatively programming a process. This joy can be witnessed by the instructor as the student moves through the learning process. This group of courses can be fun even in the midst of the many layers of confusion!

Leading to Job

How the course(s) help in the job search is best described as 'very successful'. Over the last few years, EET students have been very generous with their positive comments related to the job search. One student came to class this past year with a job offer in hand for $74K starting salary. The natural inclination was to assume the job offered a heavy travel or other unattractive component warranting the relatively high starting wave. But, contrary to this assumption, the job was for a plant electrical engineer in an established manufacturing plant only a few miles from his home, a 40 hour/week job!

Another EET student ready to graduate recently reported a starting salary of $80K with no prior experience other than co-op's. Again, no heavy travel was in the future for this student either. The most inspiring story experienced was of a former student recently graduated who showed up at a local ISA conference. He was discouraged in that he couldn't find the 'right job'. The local Siemens representative was standing a short distance away and I encouraged this former student to introduce himself. Quite a long time later, the student re-appeared beaming with a huge smile. He reported the representative had given him four promising leads. Although this student accepted a different offer, the change in his attitude was significant. And he did get the right job soon after.

Anecdotal experiences from EECS students haven't been as plentiful, yet. The course has only been taught twice with the present format and students take it in their last semester, a time in which most job offers are already in process. Some are taking the course earlier in their career and they should be better able to use the experience gained in the course together with co-op to find a better job offer.

Summary

In summary, these courses should be considered as vital for students in EECS and EET planning to enter manufacturing or automation careers. These courses should be included in the curriculum. Also, there should be no apology for their inclusion and sufficient effort expended to make sure they are taught at a rigorous level.

The reward for the effort expended in these courses will return many fold in students finding better job offers and establishing better careers in industry.

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